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CHARACTERIZATION OF MAIN EXPERIMENTAL SITES AND SUB-SITES AND QUESTIONS OF INSTRUMENTATION

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Characterization of Main Experimental Sites and Sub-sites and Questions of Instrumentation*

by

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1. INTRODUCTION

Varietal improvement and management studies to boost production and/or to enhance the stability of the crop's farming system should be directed towards components of the physical environment, in which a specific crop is cultivated rather than the crop itself. Development of improved cultivars and new technologies and their adaptation by farmers will be aided if the physical aspects of the crop environment can be described, synthesized and inventorized. Such a synthesis, eventually leading to a classification of natural environments is needed to define research priorities, to identify homologues for technology transfer, and to assist with the interpretation and analysis of trial networks.

The physical components of natural environments are elements from three systems: climate (weather), soils, and physiography (landform). They supply, directly or indirectly, water, energy, and nutrient inputs to the crop. If these components are outside the levels, critical to the crop -either permanent on temporarily- action should be taken to correct these levels. Farmers have two basic options: they can adjust their crop (or cropping system) or their choice of variety to the prevailing elements of the physical environment, or they can adjust certain elements of the physical environment to the needs of the crop. To provide farmers with proper advice, the physical aspects and their interactions should be carefully characterized, and interpreted.

Proper characterization of the physical environment of main experimental sites and sub-sites is even more essential. A detailed knowledge of the stable and variable components of the physical environment at experimental sites is the key to a better understanding of the behavior

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of the crop, its stability accross environments, and its interaction with the environments. It provides at the same time a base for extrapolation of trial results to areas with similar physical environments. This implies that characterization of the components of the physical environment of experimental sites and sub-sites should involve at least those components that are used to characterize the physical environment of the "outside world".

Characterization of the physical environment involves inventarization of two sets of data. One set comprises a long-term historic records of climatic parameters, and soil and landscape characteristics that are not variable with time. These components of the physical environment are needed to extrapolate trial results to areas with comparable physical environments. A second set consists of components of the physical environment that are variable during the trial period. These include elements of both the weather system and the soil system. This set is needed not only to interpret trial results on experimental sites, but also to compare the actual or real-time observations with the long-term historic records.

In characterization of the physical environment, consideration should be given to constraints caused by excesses as well as by deficits in energy, water, and nutrient supply. Finally, it should be noted that the physical environment also has an influence on the occurrence of weeds, insects and diseases. Characterization of the elements of the physical environment is an indispensable tool for a better understanding of the incidence and severety of pests and diseases.

2. CHARACTERIZATION OF THE CLIMATIC ENVIRONMENT

Climatic components of the physical environment supply energy and water to the crop, and indirectly influence the nutrient supply. Climatic variables do not only vary from place to place, but also in time: seasonal fluctuations and year-to-year variability. Rainfall is by far the most variable component of the physical environment, in particular in tropical regions. The humid tropics, generally characterized by an annual surplus of water from rainfall, may have periods of extreme wetness as well as distinct dry periods. Floods and drought are often occurring in the same year. Tempeature on the other hand does not show large seasonal fluctuations or great variability from year to year, at least in equatorial regions. Seasonal fluctuations however become more pronounced with latitude. Radiation follows a seasonal pattern, influenced on one hand by the exterrestrial radiation and the daylength - both factors related to latitude and month of the year -, and on the other hand by the degree and intensity of cloud cover, and thus indirectly by the rainfall pattern. Although wind speed is generally not considered as an important climatic variable for environmental characterization, it plays an important role in the process of evapotranspiration, and excessive wind speeds - typhones and tropical storms - can cause severe damage to crop. The frequency of occurrence of typhones is an important characteristic of the physical environment. Air humidity, almost always expressed as relative humidity, but preferably expressed as actual vapor pressure, is important as a variable to determine evapotranspiration. The variability of this parameter follows the same seasonal pattern as rainfall. High humidities are often related to pest and disease occurrence and should therefore be recorded. Evaporation is an extremely important climatic variable in the determination of the atmospheric water balance, which in turn is used to estimate the length of the growing season. Several methods exist to estimate evaporation from an open water surface, or potential evapotranspiration, but they can also be measured directly.

2.1 Rainfall

Rainfall is the most important climatic variable for characterization of the climatic environment. Its year-to-year variability, its seasonal pattern, and the differences over short distances all have to be noted and reported. A long historic record, frequent observations and a relatively dense network of observation sites is needed. Fortunately, instruments to measure rainfall are inexpensive and recording methods simple.

Monthly rainfall records, based on a minimum of 20 years historic records are needed for characterization of the rainfall regime at a certain location. They also form the basis of agro-ecological zones classifications. Monthly rainfall maps are also used for delineating homologues of rainfall regimes. Examples are the agro-ecological zones map of Malaysia (Nieuwolt, Zaki and Gopinathan, 1982), the agro-climatological map of Thailand (v.d. Eelaart, 1973), the agro-climatic maps of Indonesia (Oldeman, 1980), the agro-ecological zones project of FAO (1978). Panabokke (1979) prepared an agro-ecological zones map of South and South-East Asia, using monthly rainfall records, Woodhead (1970) reports on a classification of East African range lands using mean monthly rainfall records of at least 10 years record.

Most of these reports, however, indicate that monthly rainfall means by themselves do not constitute a reliable tool for characterization, because they do not inform the user of the variability of rainfall over the years. Rainfall probabilities need to be calculated as well. Hargreaves (1975) used the concept of dependable precipitation, at the 75% probability of rainfall occurrence, which is the amount equaled or exceeded in three out of four years. Oldeman (1977) found a strong linear relationship between the mean monthly rainfall and the dependable rainfall for a series of 50 year rainfall records in Indonesia: Pd = 0.82 Pm - 30. This observation was also noticed by Hancock et al. (1979), if the sample is restricted to a climatically uniform area. Jones and Cochrane (1985) reported various values for this linear regression equation in countries in Latin America, which are very similar to the above mentioned value for Indonesia (Table 1).

Table 1 - Regression equations for determining dependable precipitation

Region/Country	Regression equation	Source
Central America	Pd = 0.84 Pm - 23*	Jones and Cochrane, 1985
Brazil (Amazon region)	Pd = 0.85 Pm - 20	" " "
Colombia	Pd = 0.84 Pm - 25	" " "
Surinam	Pd = 0.77 Pm - 14	" " "
Indonesia	Pd = 0.82 Pm - 30	Oldeman, 1977
Thailand	Pd = 0.76 Pm - 20	" , 1982
southern U.S.A.	Pd = 0.84 Pm - 23	Hargreaves, 1975
Malaysia	Pd = 0.78 Pm - 32	Zaki and Nieuwolt, 1981

* Pd = dependable precipitation; Pm = mean monthly precipitation.

In order to establish these relationships experimental sites should collect and tabulate monthly rainfall records for their site and subsites for at least 25 year periods. The usefulness of monthly rainfall records is limited however. Particularly in areas where the onset and/or end of the rainy season is abrupt, as well as in areas that may have dry spells even during the rainy season, such as the breaks in the monsoons in India, Thailand, or the "veranicos" in Brazil, weekly or 10-day rainfall records are needed for a long term period. Unfortunately these more detailed rainfall totals are not often published, but main experimental sites should make an effort to retrieve this information for their regions of interest. IRRI has prepared a report on weekly rainfall records for 45 synoptic stations in the Philippines for the period 1951-1974 (IRRI, 1983). Although daily rainfall data are not considered important for environmental characterization, this information is often required as input data for deterministic models, in particular to calculate a cumulative water balance.

Generally speaking one meteorological site in an experimental farm will be sufficient to record rainfall. However if the experimental site is situated near or on a mountain slope, there may be significant rainfall variability even over short distances. For example, the experimental farm of IRRI in Los Banos is situated in the direct vicinity of Mt Makiling and there are marked differences in rainfall within a short distance. Rainfall intensity, expressed in mm hr^{-1} can only be recorded with an automatic self-registering raingauge. This information is extremely important in areas susceptible to erosion or in regions where high intensity rainfall can cause lodging of agricultural crops.

2.2 Temperature

The air temperature, usually measured with dry bulb thermometers, with maximum and minimum thermometers, or continuously recorded with a thermograph is an essential climatic variable for the characterization of main experimental sites. In the equatorial regions air temperature fluctuations over the year are relatively small and also its year-to-year variability is low. A historic record of 5 to 10 years is usually sufficient to estimate mean monthly temperatures. At higher latitudes, seasonal fluctuations become more pronounced and year to year variability becomes larger. A longer historic record is needed, as well as a summary of 10-day or weekly air temperatures instead of monthly means. At latitudes around 20° North in Asia the minimum temperatures may become critically low for tropical crops during the cold season. Under such conditions it would be useful to calculate the probability of occurrence of cold spells. At latitudes around 25° North in Asia the daily minimum temperature in the cold season drops to a level that restricts crop production. The length of the growing season is now determined by temperature. Particularly when the onset or end of the cold season is rather sharp, short period (weekly or 10-day) long term historic data are needed to calculate probabilities. At these latitudes crop growth is not only constrained by low night temperatures in winter, but also by extremely high day temperatures, that may cause severe damage -sterility- in crops. These periods of high maximum temperatures also have to be characterized. These extremes in both maximum and minimum temperature clearly demonstrate that characterization of main experimental sites with only the monthly mean air temperature - average of the maximum and minimum temperature - is not very meaningful. Temperature variables needed for characterization should include maximum and minimum temperatures. These variables can then be used to calculate daily means or to estimate the day-time and night-time temperature (Gommes, 1983).

Finally a common way to estimate air temperature in the equatorial regions - if no actual records are available - is to relate air temperature to elevation above sea level. For Indonesia Oldeman (1978) calculated highly significant regression equations for the maximum and minimum temperature in relation to altitude: $T_{max} = 31.3 - 0.0062X$ and $T_{min} = 22.8 - 0.0053X$ (T in ° Celsius and X in m.). For Latin America, Jones and Cochrane (1985) found a similar relationship: a decrease of 5.5°C for every 1000 m increase in elevation.

2.3 Radiation

Levels of radiation will never prohibit crop production. Their information is of particular importance to estimate ceilings of crop production, as it is the source of energy that green plants can convert into chemical energy through the process of photosynthesis. In addition the radiation balance determines the rate of evaporation, which information is needed to calculate the water balance. Total radiation can be measured directly by a variety of instruments with varying degrees of sophistication and accuracy. In the past radiation was more commonly estimated from degrees of cloudiness or from hours of bright sunshine. The most commonly used relationship was established by Prescott (1940): $Rg/Ra = a + b \times n/N$, in which Ra (exterrestrial radiation, falling on a horizontal surface at the limit of the atmosphere) and N (astronomically possible hours of sunshine duration) can be read from existing Smithsonian tables, n is the hours of bright sunshine per day, Rg is the total radiation, while the coefficients a and b have to be established empirically. Table 2 gives some values established in various regions.

Table 2 - Coefficients a and b for the conversion equation to calculate radiation from hours of bright sunshine $Rg = Ra\ (a + b \times n/N)$

Location	a	b	Source
U.K. and Ghana	0.18	0.55	Penman (1956)
Nigeria	0.19	0.60	Davies (1965)
Los Banos, Philippines	0.24	0.54	Robertson (1971)
Singapore	0.22	0.48	Oldeman and Frère (1982)
Kuala Lumpur	0.29	0.42	" " "
cold and temperate climates	0.18	0.55	Frère and Popov (1979)
dry, tropical zones	0.25	0.45	" " "
humid, tropical zones	0.29	0.42	" " "

Based on relationships between relative sunshine duration (n/N) and the coefficients a and b (Frère, Rijks, and Rea, 1975), tables to calculate monthly values for the expression a + b x n/N were developed by Oldeman and Frère (1982).

A rough guide to convert degrees of cloudiness, usually expressed in Octas, into relative sunshine duration is given by Doorenbos and Pruitt (1979). Reddy (1974) established a relationship between degree of cloudiness (a in Octas) and relative sunshine duration in relation to latitude (L in degrees), based on observations in India:

$$n/N = 1 - (\frac{a}{8} \times e^{-0.25\ a/8}) - (0.02 + 0.85\ \text{Cos}\ L).$$

Oldeman and Frère (1982) found that at least for the humid tropics of Southeast Asia, both conversion guides underestimated the value n/N as illustrated in figure 1.

2.3.1 Radiation equipment

Because of the paucity of actual measured data on total radiation at experimental sites and its importance in establishing causal relationships between total radiation and crop production, the rice-weather project, jointly carried out by IRRI, WMO and national agricultural research institutions in Asia, Africa, and Latin America, installed radiation equipment at 22 experimental sites (Oldeman, Seshu, Cady, 1986). The following requirements guided their choice of equipment:

- Simplicity in observation procedures
- Low level of maintenance requirements
- Weather-proof under humid tropical conditions
- No need for frequent recalibration
- Self contained (no need for reliable source of power).

At each of the 22 experimental sites two instruments were installed to measure total radiation.

- The RIMCO electronic integrating pyranometer, type R/E1P, manufactured by Ranchfuss Instruments Division at Oakleigh, Australia. This self-contained weather proof, sturdy, direct reading and easily installed pyranometer has a sensing head containing 23 silicon solar cells. One 20 mm^2 cell senses total solar radiation in the region 300 to 4000 nm, while the other cells provide necessary power to maintain the internal batteries that drive the integrator and digital counter, adjusted so that one count is equivalent to 1 mWhr cm^{-2}. When tested against a standard "Kipp and Zonen" solarimeter, an almost perfect correlation was found. The instrument is relatively expensive, but during its two years in operation at 22 sites no problems were encountered and a daily radiation record was obtained.
- The Gunn Bellani solar radiation integrator, manufactured by Baird and Tatlock, at Romford, England. This instrument provides a time-integrated assessment of radiation falling on a black body by measuring the volume of liquid (usually water, which is contained in a thin walled copper sphere blackened externally) distilled in a receiving graduated tube. Sealed to the upper portion of the distillation tube and surrounding the copper sphere is a glass envelope. Air pressure between the copper sphere and the glass envelope is reduced to 1 mm Hg. Before this equipment can be put to use, it has to be calibrated against a direct recording solarimeter. In the rice weather studies this calibration was achieved with the Rimco (see figure 2). The major advantage of this instrument is its low cost, simple

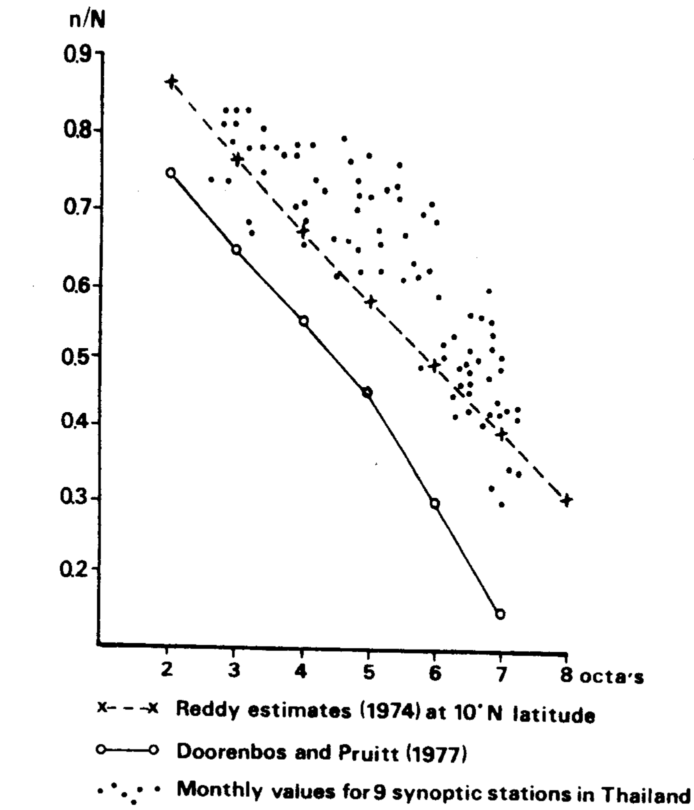

Figure 1. Relation between cloudiness (in octa's) and relative sunshine (c/N).
Source: Oldeman and Frère, 1982.

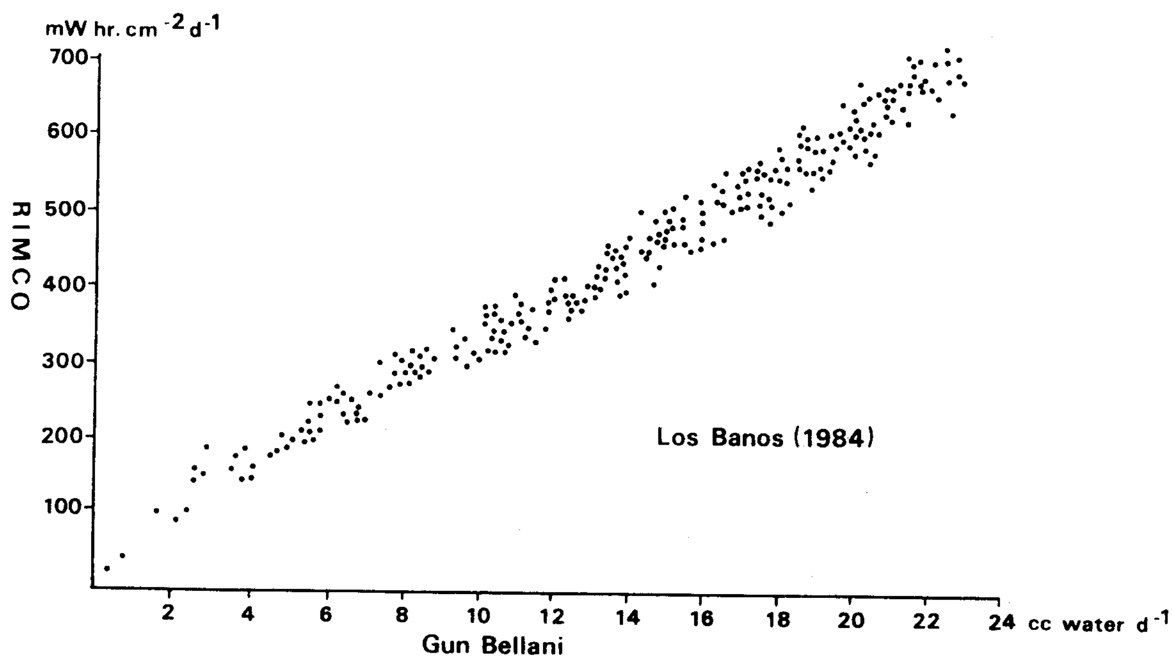

Figure 2. Relation between daily Gunn Bellani units (cc water per day distilled) and total solar radiation, recorded with the RIMCO solarimeter at Los Banos, Philippines.
Source: Oldeman, Seshu and Cady, 1986.

observation procedures, absence of any mechanical or electronic parts that may have to be replaced. The instrument seems to be well suited to be installed in a local network of experimental sites, provided that they can be calibrated against a direct recording solarimeter at the main experimental site. A disadvantage is its sensitivity to extreme temperatures, but particularly for the equatorial regions where seasonal temperature fluctuations are small, this is not a serious problem.

2.4 Relative humidity

Mean monthly values of the relative humidity may be sufficient for characterization of main experimental sites, provided that also the mean monthly mean air temperature is given. A much more meaningful expression of the humidity of the air is the actual vapor pressure of the air. The air humidity is usually measured with a psychrometer, consisting of a dry bulb thermometer and a wet bulb thermometer. The wet bulb thermometer should be force-ventilated, particularly in the humid tropics where wind speeds are very low. Often the relative humidity is measured with a direct recording thermohygrograph. Although the seasonal fluctuation of the humidity is relatively small, daily fluctuations can be high and therefore an additional measurement of the minimum humidity can be an important addition for characterization. Very low humidities combined with high wind speed can cause severe sterility in grain crops.

2.5 Wind speed

Wind speed is usually measured with an anemometer that indicates a numerical value of total wind run. Mean monthly values of 24 hour wind speed are usually reported, but in areas where there is a great difference in day and night wind speed, this information is important for a proper characterization of the experimental sites. Information on wind speed is not only important for the estimation of potential evapotranspiration but also in experimental sites where sensitivity to lodging is studied. Of particular importance is information on the probability of occurrence of tropical storms and typhoons in areas commonly affected by these tropical disturbances.

2.6 Evaporation

Although evaporation is usually listed as a climatic variable, it is a physical process by which a liquid (or solid) is transformed into the gaseous phase. The most commonly accepted equipment to measure evaporation from open water surface is the standard class A evaporation pan. Although instructions for installation of the pan and methods of recording are clearly spelled out, and requirements to maintain the pan (and the water in the pan) are known, experience has shown that recorded data from these pans are often dubious or inaccurate. In addition, the number of sites with direct evaporation records is limited. Therefore more emphasis is placed on the measurement of other weather variables that can be used to estimate the rate of evaporation. Empirical relationships using only temperature are inadequate, particularly in tropical regions where air temperature fluctuations are minimal. Air temperature, radiation balance, humidity and wind speed are all necessary to estimate evaporation. The Penman method, which involves the calculation of the net radiation term, the aerodynamic term and a correction term is generally accepted. Jones and Cochrane (1985) used Hargreaves' equation, based on solar radiation and mean temperature, to estimate potential evapotranspiration: ETP = 0.075 x RSM x TMF, in which RSM is solar radiation, converted to equivalent mm of evaporation per month, and TMF is the mean monthly temperature in degrees Fahrenheit. For characterization of experimental sites and sub-sites monthly values of total evaporation (or potential evapotranspiration) are required, mainly to determine the water balance, the length of the growing season (FAO, 1978), agricultural rainfall index (Nieuwolt e.a., 1982) or moisture availability index (Jones and Cochrane, 1985). It is also used to determined crop water requirements.

A word of caution is needed for experimental farms that have physiographic differences or cultivation differences within the area, or marked topographic features nearby. In such areas actually measured or empirically established values of potential evapotranspiration may be quite different at locations very close together. At the IRRI experimental farm an average of 200 mm difference in annual evaporation was found between the "lowland farm", where the fields are cultivated for wetland rice throughout the year and the adjacent "upland farm", where dryland crops are cultivated. Particuarly during the dry season monthly evaporation is 10 to 15% lower in the lowland farm than in the upland farm.

2.7 Manual and automatic weather measurements

Real-time weather variables are usually recorded manually. The Benchmark Soil Project installed battery-operated mechanical weather stations within their experimental sites and also as back-up a standard rain gauge and a max-min thermometer. Global solar radiation was recorded with a Li-Cor pyranometer sensor and mechanical integrator. Rainfall, air temperature, relative humidity, wind direction and wind speed were recorded on a strip chart. The rechargeable battery in the weather station was replaced on a monthly basis. With both manual and automatic instruments a reasonably good set of daily weather records across a network of 17 sites was obtained. According to the project manager of BSP the qality of individuals involved in weather recording is the key to monitoring and recording of good weather records (Pers. comm.). This experience was also felt with the 22 sites in the rice-weather studies with only manually recorded weather variables. A major concern with automatic recording is the possibility that the observer takes the recording for granted. He is not actively involved except for changing the charts and the batteries. Another concern is the possible failure of operation of automatic instruments. A manual back-up set is needed. Since manual recording of real time weather variables generally does not take more than 30 minutes per day - every day of the year - the necessary labour input can be met by main experimental sites.

3. CHARACTERIZATION OF THE EDAPHIC ENVIRONMENT

Agro-ecological significant aspects of the edaphic environment are those components that have a direct or indirect impact on the water and nutrient supply to the crop. While climatic variables need to be monitored for a long historic period and mostly on a daily basis in order to arrive at satisfactory means or probability levels, most soil and landform characteristics need to be observed, analyzed and/or described only once (or a few times during the growing season for some soil chemical and hydrological characteristics). While there are numerous national and international organizations that have surveyed landforms and soils at many different levels of detail, it is surprising that detailed soil surveys of main experimental sites and subsites are often not available.

In many experimental sites characterization of the soil is limited to a description of a few soil components of the topsoil or the plough layer. Brinkman e.a. (1982) stated that "the fallacy that rice roots would voluntarily limit themselves to the ploughed layer has inhibited - though not totally prevented - the study of deeper horizons, of other land characteristics than those of the soil profile itself, and of soil moisture movement". In the proceedings of an IRTP/INSFFER* monitoring programme on rice improvement for adverse soils (IRRI, 1984), some soil characteristics for experimental sites are given but without even mentioning for which depth they were sampled. It was recommended by the monitoring team among others, that

- more attention be given to a complete characterization of test sites;
- more emphasis be given to the classification of adverse environments;
- some soil chemical data be collected at least 3 times during the growth period (those that do not remain constant during that period).

Land and soil characterization should be done in a standardized way, so that results can be stored in an accessible format and readily exchanged with researchers. Fortunately, in our technologically advancing age, the detailed descriptions and comparison of the many properties of sites can be handled by coding and computerization. On a regional level a geographic reference base of the land systems for tropical America was prepared for their main features in terms of climate, landscape and soils (Cochrane e.a., 1985). The landscape was subdivided into land systems, delineated on 1:1,000,000 satellite imagery and for some areas on side-looking radar imagery, when it was not possible to obtain cloud free imagery for many high-rainfall areas. Land systems are defined as "physiographic units, based on repetitive patterns of topography, vegetation, and soils, within a given climatic circumstance". Field work was carried out to provide ground control, to help standardize descriptive criteria, and to study the variation of landscape features within the land systems. The proportion of these variations, "land facets", were estimated and the most extensive soils in each land facet were first classified as far as the Great Group category

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*International Rice Testing Program/International Network on Soil Fertility and Fertilizer Evaluation for Rice of the Soil Taxonomy system (Soil Survey Staff, 1975) and then described in terms of their main physical and chemical properties. Soil physical properties coded include slope, texture, presence of coarse material, depth, initial infiltration rate, hydraulic conductivity, drainage, moisture-holding capacity, temperature regime, moisture regime, and presence of expanding clays. Soil chemical properties coded include pH; percentage Al saturation, exchangeable Al, Ca, Mg, K, Na; total exchangeable bases; effective cation-exchange capacity; organic matter; available P; P-fixation; available soil Mn, S, Zn, Fe,m Cu, B, and Mo; free carbonates; salinity; percentage of Na saturation; presence of acid sulphate soils; X-ray amorphism. The soil chemical properties were summarized separately and also coded according to the Fertility Capability Soil Classification System (FCC), devised by Buol et al. (1975).

On a global scale minimum data inputs for a digital data base should consist of interactive cartographic, landscape, soil and meteorological data files. A list of minimum data inputs was proposed during the First International Workshop on the Structure of a Digital International Soil Resources Map annex Data Base, held under the auspices of the International Soil Science Society (Commission V, working group), at the International Soil Reference and Information Centre, Wageningen in January 1986. The suggested list of landscape attributes included elevation (mean and range); surface form; origin and kind of material; slope gradient; slope length; land use, vegetative cover and forms of degradation; flooding; stoniness; patterned ground (such as permafrost, polygons, mounds, gilgai); surface water and drainage; groundwater. For the suggested list of soil attributes at least three layers (surface, subsurface, subsoil) should be included for the following characteristics: organic carbon; cation exchange capacity (CEC); effective CEC; anion exchange capacity; base saturation; exchangeable cations; pH; electrical conductivity; texture and coarse fragments; available water capacity; bulk density; wetness; structure and consistence; rooting depth and biological activity; presence of gypsum and calcium carbonate; color and mottling; diagnostic horizons and compacted layers.

Brinkman (1981) prepared detailed guidelines for site characterization of main experimental sites and subsites for wetland rice. The kind of data to be collected can be distinguished in two sets:

- those qualities that are suspected to be limiting; quantitative measurements are needed to establish the degree to which they limit production;

- those land qualities that are probably not limiting: measurements or observations are desirable to establish that the land is indeed within a safe range with respect to these qualities.

This draft guideline for site characterization was made with a minimum of technical terms, as it was intended to be used by non-specialists. It should include enough features that can be observed in the field, so that it at least enables a correlation to be made of the main explanatory variables with easily identifiable land characteristics within a certain soil-landscape region.

In contrast with the characterization of the climatic environment of the experimental sites and subsites, where one or two observation points are generally sufficient, many observation points are usually needed to characterize the soils on the experimental sites. It should be said that the word "experimental site" in the title of this paper is interpreted as the area of the experimental farm and not as a particular field on the farm.

A possible format for the retrieval of edaphic components to characterize experimental sites is given as Appendix 1. This format is based on the guidelines Brinkman (1981) prepared for use in the INSFFER network. Since these guidelines were particularly geared to rice experiments, it has been adapted here for a more general use. Also included are some of the landscape attributes suggested by the International Workshop on the Structure of an International Digitized Soil Resources Map annex Data Base. Together with components of the climatic environment as discussed before, they form the necessary base to diagnose those conditions at a site that may limit yield or response to management practices. Experimental sites can be compared and results from many sites can be grouped and yield differences explained by observed features of the environment. Finally, research results from main experimental sites can be extrapolated to farmer's fields with similar environmental conditions.

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APPENDIX 1 - Characterization of Experimental Sites

Components of the land and soil environment needed to locate and characterize experimental sites are listed under 5 headings: General information; Landform; Hydrology; Land Use; Soils. The listed components are not to be considered exhaustive, but reflect minimum data requirements suggested by various national, regional, and international workshops on this subject. The main objective of this listing is to provide some uniformity of information among the numerous experimental sites where international and national agricultural research institutions carry out their research activities.

Particularly with respect to soil profile descriptions and soil physical and chemical properties standardization of the information is essential. Reference is made to existing guidelines for soil profile description (FAO, 1977), laboratory methods and procedures for collecting soil samples (FAO, 1970; Soil Conservation Service, 1972), while attention is drawn to the LABEX activities (Laboratory Methods and Data Exchange Programme), coordinated by the International Soil Reference and Information Centre, at Wageningen, the Netherlands, which has a major objectives to improve soil classification and soil correlation, and to provide a reference base for soil laboratories (Van Reeuwijk, 1984). At present 85 soil laboratories around the world are participating in this programme (Pleijsier, 1986).

Appendix 1. Format for characterization of experimental sites:

A GENERAL INFORMATION

1) Name experimental site: ______________________________;
2) Total area of site: ____ ha.;
3) Name nearest village: ________________; Distance ____km; Direction: ____________; 4) District: ________________;
5) Province: ____________________; 6) Country: ______________;
7) Latitude __°__' N/S; 8) Longitude: __°__' E/W; 9) Elevation ______m.

B LANDFORM of experimental site

1) Surface form: level / inclined / steep / undulating / humocky / rolling other: ____;
2) Origin and kind of material: alluvial / colluvial / aeolian / volcanic / marine / sandstone / limestone / igneous / other: ________________;
3) Slope gradient: __%; 4) Slope length ______ m; 5) Slope shape: convex / straight / concave;
6) Position of site in landscape: top of the hill / along slope / bottom of the hill / valley floor / (width of valley floor: ____ m);
plain (nearest hills are _____ km away; height of hills: ______ m);
other: ______________________________

C LAND USE of arable land around exp. site but on same general landform as exp. site

1) Wetland rice: yes / no; usually one / two rice crops per year; average crop yield: _______ t/ha;
2) Wetland rice in rotation with other crops: yes / not normally / never. If yes: major crops in rotation with rice:

________________ average yield ________ t/ha
________________ average yield ________ t/ha
________________ average yield ________ t/ha

3) Upland crops as monoculture or in rotation with other crops:

crop: _______________ yield ________ t/ha. Percentage of area ___ %

_______________ ________ ___

_______________ ________ ___

4) Major crops cultivated on the experimental site:

crop: _______________ yield ________ t/ha. Percentage of site ___ %

_______________ ________ ___

_______________ ________ ___

C HYDROLOGY of experimental site

1) Surface water: nearest open drain / creek / river is _____ m / more than 1 km from site

during dry season site is ________ m above normal water level of nearest surface water

during wet season site is ________ m above normal water level of nearest surface water / or: at normal water level of nearest surface water / or: normally flooded to ______ cm depth. Flooding normally lasts ____ weeks from _______________ to ______________

2) Subsurface water: groundwater depth during dry season ____ cm below surface / or more than 2 m below surface / unknown;

groundwater depth during wet season ____ cm below surface / or more than 2 m below surface / unknown.

Seepage occurs from higher areas into site: yes / no / unknown.

If yes: for most of the year / for about ____ weeks / from _____ to _____.

Upwelling water occurs from below to surface: yes / no / unknown.

If yes: for most of the year / for about ____ weeks / from _____ to _____.

3) Irrigation: available throughout the year / available from _______ to ________ / not available.

Method of irrigation: surface / sprinkler / drip / other: _______________

if not irrigated: primary source of water: rainfall only / rainfall + runoff / storage dam / open well / tube well / other: ____________________

4) Reliability of water supply (including rainfall and irrigation) to the site is

	for upland crops		for wetland rice (if applicable)	
dependable and sufficient	from ________	to ________	from ________	to ________
erratic or insufficient	from ________	to ________	from ________	to ________
excessive (flooding)	from ________	to ________	from ________	to ________
not available	from ________	to ________	from ________	to ________

D SOILS

I <u>Availability of information on soils and topography of site and surrounding area</u>:

1) Soil map of the site available: yes / no. Scale ______________

2) Topographic map of the site available: yes / no. Scale ____________

3) Contour map of the site available: yes / no. Contours at _______ m intervals

4) Soil map of the area in which site is located available: yes / no.
Scale of most detailed soil map: ____________, published when: ________
Prepared by: ____

5) Soil profile descriptions of major soils on the site available: yes / no

6) Soil monoliths of major soils of the site available: yes / no

7) Soil physical and soil chemical properties of major soils available: yes / no

8) Experimental site has its own analytical soil laboratory: yes / no
Soil samples are analyzed elsewhere: ______________________________

II Soil classification

1) Major soils delineated on the experimental site:

	Local series or family name	Great Groups according to: U.S. Taxonomy	FAO/Unesco	Area (ha)
a:	______	______	______	___
b:	______	______	______	___
c:	______	______	______	___
d:	______	______	______	___

2) Major soils surrounding experimental site but on similar landform as exp. site:

	Local series or family name	Great Groups according to: U.S. Taxonomy	FAO/Unesco	Area (ha)
a:	______	______	______	___
b:	______	______	______	___
c:	______	______	______	___
d:	______	______	______	___

III Soil characteristics for each major soil and each profile horizon,

recognized in the field (at least three layers: surface, subsurface, subsoil). Note analytical methods used and attach sketch or map of experimental site with location of sampling sites.

Soil a: ____________________ depth from ______ cm to ______ cm.

1. Texture
2. Color
3. Mottles (color, size, abundance)
4. Fe and Mn nodules
5. Structure
6. Consistence (wet, moist, dry)
7. Pores (size, shape, abundance)
8. Roots (size, abundance)
9. Transition to next horizon
10. pH (1:1 H_2O; 1:2.5 H_2O; 1:1 KCl; other: ________)
11. Cation, effective cations, and Anion Exchange Capacity:
12. Exchangeable cations: Ca, Mg, K, Na, Al
13. Base saturation

14. P available (Olsen / Bray / other: __________)
15. Total N
16. Organic C (Walkley-Black / Allison / other: __________)
17. Presence of gypsum and calcium carbonate (reaction with HCl)
18. Clay content (2 µm)
19. Silt content (2-50 µm)
20. Sand content (50 µm)
21. Bulk density
22. Total pore space
23. Soil moisture at field capacity
24. Soil moisture at wilting point
25. Other characteristics:

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